(2)

BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Chairman, Committee on Armed Services, United States Senate

Performance Capabilities Of The C-5 And C-17 Cargo Aircraft

The performance capabilities of the Air Force C-5A/B and C-17 cargo aircraft, including their use at small, austere airfields, have been the subject of considerable discussion within the Department of Defense and the Congress. Conflicting information has been presented on these aircraft.

This report discusses information GAO obtained from the Air Force and contractors on the feasibility of using the C-5A/B and C-17 for small, austere airfield operations. Information on other characteristics and performance capabilities of each aircraft is also discussed.

UNITED STATES GENERAL ACCOUNTING OFFICE

GAO/NSIAD-84-119
JULY 9, 1984

Request for copies of GAO reports should be sent to:

U.S. General Accounting Office
Document Handling and Information
Services Facility
P.O. Box 6015
Gaithersburg, Md. 20760

Telephone (202) 275-6241

The first five copies of individual reports are free of charge. Additional copies of bound audit reports are $3.25 each. Additional copies of unbound report (i.e., letter reports) and most other publications are $1.00 each. There will be a 25% discount on all orders for 100 or more copies mailed to a single address. Sales orders must be prepaid on a cash, check, or money order basis. Check should be made out to the "Superintendent of Documents".

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

NATIONAL SECURITY AND
INTERNATIONAL AFFAIRS DIVISION

B-215103

The Honorable John G. Tower
Chairman, Committee on Armed Services
United States Senate

Dear Mr. Chairman:

In accordance with your letter, dated April 25, 1984, here is our report comparing the capabilities of the C-5 and C-17 cargo aircraft. This report discusses Air Force and contractor information on the feasibility of using the C-5A/B and C-17 cargo aircraft in small, austere airfield[1] operations. It also discusses other general characteristics and performance capabilities of both aircraft.

The C-5A/B and C-17 differ in design and performance capabilities. However, because of the overall similarities in the mission of each, the need for a new aircraft has caused considerable discussion within both the Department of Defense and the Congress since 1980. Conflicting information has been presented on the capabilities of these aircraft, including the suitability of their use at small, austere airfields. To compare the overall capabilities of each aircraft, we requested and reviewed relevant Air Force and contractor information. We placed emphasis on the small airfield capability of each aircraft because it has been a major issue. The results of our review are summarized below and are presented in greater detail in appendixes I and II.

Although the manufacturer disagrees, the Air Force, based on its 13 years of C-5A experience, believes that neither the C-5A nor the C-5B can routinely and safely land or takeoff from small, austere airfields. The Air Force states that these operations would require operating near the limits of aircraft and aircrew capability with very little margin for safety. The Air Force further advised us that the C-5A/B is not suited for small airfield ground operations because of its large size and lack of maneuverability. It states that the C-5A/B ground operations at small, austere airfields are difficult or impossible because of obstructions and the size of the taxiways. For these reasons, the Air Force states it will continue to restrict routine operations

---

[1]The Air Force generally defines a small, austere airfield as one that has runways less than 4,000 feet, has less than 100,000 square feet of ramp space, and lacks a ground support capability.

of the C-5A/B to runways 5,000 feet or longer. Although the C-5A/B has the capability to operate on unpaved surfaces, the Air Force states it will not base plans for wartime operations on this capability.

The Air Force and Lockheed-Georgia Company, the C-5A/B contractor, provided us differing estimates of aircraft takeoff, landing, and payload/range capabilities. Although Air Force and contractor estimates varied because of differing assumptions, the data provided by both show that the C-5B can carry its 261,000 pound maximum payload long distances without being refueled and that it can land in short distances. Air Force data show that the C-5B can carry 261,000 pounds of cargo 1,530 nautical miles; contractor data estimates it could carry such cargo 2,713 nautical miles. Data provided by both show it can land within 2,600 feet or less with 170,000 pounds of cargo.

Data provided by the Air Force and McDonnell Douglas Corporation, the C-17 contractor, show that the C-17 is designed to carry its 172,200 pound maximum cargo load an unrefueled distance of about 2,900 nautical miles. This data also show that the C-17 will be able to land in 2,370 feet with a cargo load of 170,000 pounds.

The C-17 will have several unique design features that, according to the Air Force, will enable it to routinely and safely takeoff, land, and operate at small, austere airfields. The C-17's advantages in the small, austere airfield environment include its smaller size, better maneuverability using its backup capability, and its combat offload capability. The Military Airlift Command states that the C-17 will be able to perform any type of mission currently assigned to the Command, including tactical airlift missions currently performed by the C-130.

Appendix III provides the objectives, scope, and methodology used for our review.

We are sending copies of this report to the Chairmen, Subcommittees on Defense of the House and Senate Committees on Appropriations; the Chairman, House Committee on Armed Services; and the Secretaries of Defense and the Air Force. We will also make copies available to others upon request.

Sincerely yours,

Frank C. Conahan

Frank C. Conahan
Director

HISTORY AND CURRENT STATUS OF AIR FORCE CARGO AIRCRAFT ACQUISITION PROGRAMS

RECENT PROGRAM HISTORY

In 1979 the Air Force initiated the C-X program to increase the military's capability to airlift outsized cargo[1] over intercontinental ranges. A C-X Request for Proposal (RFP) was released to industry in October 1980 inviting proposals for new designs as well as alternate proposals using existing designs. The RFP required the C-X (1) have both intertheater and intratheater capabilities, (2) carry outsize cargo, and (3) operate into small, austere airfields. The Boeing Company and McDonnell Douglas Corporation submitted new designs and the Lockheed-Georgia Company submitted a new design as well as an alternate proposal for restarting production of the C-5. In April 1981 the Air Force announced that Lockheed's alternate proposal to restart production of the C-5 did not meet the minimum C-X requirements. In August 1981 the Air Force announced that the McDonnell Douglas C-17 was the winner of the C-X competition.

In January 1982 the Air Force announced its decision to acquire 50 Lockheed C-5B cargo aircraft and 44 McDonnell Douglas KC-10A tanker/cargo aircraft under its airlift enhancement program to increase intertheater airlift capability in the near term. The C-5B is a modified C-5A with the same overall capabilities. According to the Department of Defense, the overriding consideration in the choice between restarting production of the C-5 and developing the C-17 was the urgent need to increase outsize, intertheater airlift capability as quickly as possible. The Air Force stated that the C-5B would be available 2 to 3 years sooner than the C-17 because of existing production tooling, engineering drawings, and qualified sources of supply. With the heightened awareness that readiness was absolutely dependent on responsive and capable airlift, Defense resolved to try to fix the problem sooner by increasing funding for near-term airlift procurement starting with fiscal year 1983.

Because of similarities of the C-5A/B and the C-17, the need for a newly designed aircraft has continued to cause considerable debate within both Defense and the Congress. While the two aircraft differ in detailed design and specific performance capabilities, similarities between the two include the fact that each

[1]Outsize cargo includes items such as tanks, artillery, large trucks, helicopters, and large contruction equipment. The C-5A is the only existing Air Force aircraft designed to carry outsized cargo.

was designed to carry outsize cargo over intercontinental distances and land at small airfields. Much of the controversy has centered around the overall capabilities of both aircraft, including their use at small, austere airfields. For example, proponents of the C-5A/B have pointed out that they can carry greater cargo loads and can use runways as short as 3,000 feet in length. The Air Force has maintained that it is not practical to use the C-5A at small, austere airfields and has restricted its use to runways of 5,000 feet or longer. Although the C-17 carries less cargo, the Air Force states that its smaller size and modern technology increase its capability to use small, austere airfields.

The Air Force's C-5As, which have been operating under weight and flight restrictions due to understrength wings, are being modified with a stronger wing which will permit an unrestricted additional flight life of 30,000 hours. The C-5B will have the same wing as the modified C-5A. Maximum takeoff and landing gross weights and maximum zero fuel weights will be identical and each will perform the same on takeoff and landings at a given weight.

The Air Force Airlift Master Plan, dated September 1983, contains recommendations for improving and increasing airlift capability. These include acquisition of the C-17 as a follow-on to the C-5B program and the retirement of older C-130s and C-141s in the 1990s. The C-17s would replace the active fleet of C-141B strategic (intertheater) aircraft, which would be transferred to the Air Force reserves. According to Defense, the C-17's primary role would be strategic, and it would not be a replacement for the C-130. However, Defense states that the C-17 has performance characteristics which also allow it to operate into airfields previously suitable only for C-130 tactical (intratheater) aircraft. As a result, it would be able to direct deliver over intertheater distances, combining an intertheater and intratheater airlift movement and reducing the demand on the C-130 airlift fleet and congested main operating bases. The C-17 could also supplement the C-130, especially in high volume operations where one C-17 mission, because of its greater payload capability, could replace several C-130 missions.

STATUS OF C-17 AND C-5B PROGRAMS

In July 1982 the Air Force awarded a contract to McDonnell Douglas for a modestly paced C-17 research and development program. The $31.6 million effort was funded using fiscal year 1981 money, which the Congress provided for the study of various airlift alternatives. Awarding this contract preserved the Air Force option to develop the C-17 in the future. As of September 30, 1983, funds on the contract had been increased to about $87.2 million. Current Air Force plans call for the production of 211 C-17s at a total program cost of $39.8 billion (then year

dollars), including the cost of development. This is equivalent to $19.5 billion in constant fiscal year 1981 base year dollars. This cost will be incurred beginning in fiscal year 1981 and ending in fiscal year 1998.

In October 1982 the Air Force awarded Lockheed a $50 million contract for C-5B preliminary production and procurement of long lead materials. The Air Force awarded a modification to the contract on December 31, 1982, for full production. The fixed-price contract modification provided for one C-5B aircraft to be delivered December 31, 1985, under the fiscal year 1983 program and options for 49 additional aircraft. The fiscal year 1984 C-5B program provides for the acquisition of four aircraft. The last aircraft under the contract would be scheduled for delivery in March 1989. The total program cost for all 50 aircraft is estimated at $9.4 billion (then year dollars). This is equivalent to $5.7 billion in constant fiscal year 1980 base year dollars.

CHARACTERISTICS AND CAPABILITY

OF C-5A/B and C-17

CARGO AIRCRAFT

The first part of this appendix compares the technical characteristics of the C-5A/B and C-17. The latter part is a discussion that focuses on the ability of these aircraft to use small, austere airfields and on certain other performance capabilities.

SELECTED C-5B AND C-17 TECHNICAL INFORMATION

The C-5B, being built by the Lockheed-Georgia Company, is an air-refuelable, long-range aircraft designed to airlift a variety of combat support equipment and personnel. The C-5B, like the C-5A already in the Air Force fleet, will be capable of carrying outsize cargo. The C-5B will be powered by four General Electric TF-39-1C turbofan engines with 41,100 pounds of thrust which are equipped with fan thrust reversers. It can produce an additional 1,900 pounds of thrust if needed.

Some unique design features of the aircraft are forward and rear cargo door systems, which allow straight-through loading and unloading, and a landing gear kneeling system, which enables the cargo deck to be tilted nose or tail down or to be lowered in the level position. The high flotation, retractable landing gear consists of four, six-wheel main landing gear and a four-wheel steerable nose gear.

The C-17, to be built by the McDonnell Douglas Corporation, is a long-range, air-refuelable aircraft. It is also designed to carry outsized cargo. It will be powered by four 37,000 pound thrust Pratt and Whitney PW2037 engines, which are to be used on the Boeing commercial 757. The engines will have both fan and core thrust reversers, which will direct the jet exhaust both forward and upwards.

According to the Air Force, the C-17 will be designed to perform the full range of airlift missions in its intertheater and intratheater roles--airland, airdrop, combat offload, medical evacuation, and low and normal altitude parachute extraction of various types and sizes of cargo. It is designed to carry a maximum payload of about 86 tons an unrefueled distance of 2,940 nautical miles and, according to the Air Force, deliver this payload directly and in a safe and routine manner into small, austere airfields.

The data in the table beginning on page 6 were provided by the Air Force, Lockheed-Georgia Company, and McDonnell Douglas Corporation. The data provided by the Air Force and McDonnell Douglas Corporation on C-17 performance capabilities were essentially the same and were based on ground rules specified in the C-X RFP. However, the Air Force and Lockheed-Georgia Company provided differing C-5B performance capability estimates for several performance parameters, including takeoff and landing distances.

The Air Force generally bases its C-5B performance estimates on C-5A flight manual data, which were derived from C-5A flight testing. Lockheed states its estimates incorporate enhanced capabilities available with the new wing design and differing takeoff and landing rules specified in the C-X RFP. Lockheed believes using C-X RFP ground rules for both the C-17 and the C-5 permits a direct comparison of the two aircraft. The Air Force considered the C-X ground rules inappropriate for application to the C-5B. Lockheed believes these rules are operationally feasible, although they do differ from the flight manual. Use of the C-X RFP flight rules in estimating C-5B performance generally has the effect of decreasing takeoff and landing distances.

Differences between the C-5A flight manual and the C-X RFP landing rules include the degree of aircraft glide slope, approach speed, and engine reverse thrust procedures.

C-17 AND C-5 CHARACTERISTICS AND SELECTED DATA ON THEIR TAKEOFF, LANDING, AND OPERATING CAPABILITIES

Description	C-17 Air Force	C-5B Air Force	C-5B Lockheed
Overall length	175.2 ft.	247.8 ft.	247.8 ft.
Wing span	165.0 ft.	222.8 ft.	222.8 ft.
Tail height	55.3 ft.	65.0 ft.	65.0 ft.
Number of nose landing gear wheels	2	4	4
Number of main landing gear wheels	12	24	24
Outside dimension of main landing gear tread	33.7 ft.	37.5 ft.	37.5 ft.
Type engines	PW2037	GE TF39-1C	GE TF39-1C
Engine thrust	37,000 lbs.	41,100 lbs.	41,100 lbs.
Normal cargo floor height	65.0 in.	104.1 in.	104.1 in.
Cargo floor height at kneeling level	N/A	71.5 in.	71.5 in.
Width of air drop cargo opening	216 in.	156 in.	156 in.
Height of air drop cargo opening	126 in.	114 in.	114 in.
Combat offload capability	yes	no	no
Low altitude parachute extraction system (LAPES)	yes	no	no
Minimum air crew size	3	8[a]	4

Description	C-17 Air Force	C-5B Air Force	C-5B Lockheed
Number of passengers in peacetime	102	73	73
Number of troops carried in peacetime	102	83	90
Maximum number of troops carried with palletized seats	134	353	360
Maximum number of 463L pallets	16	36	36
Optional number of 463L pallets using ramps	18	36	36
Empty operating weight with no useable fuel or payload	236,633 lbs.	374,000 lbs.	374,000 lbs.
Maximum payload at maneuver load factor of 2.25 times the force of gravity[b]	172,200 lbs.	261,000 lbs.	261,000 lbs.
Fuel capacity (1 gal. weighs 6.5 lbs.)	176,200 lbs.	332,500 lbs.	332,500 lbs.
Fuel consumption per flying hour	2,169 gal.	3,340 gal.	3,350 gal.
Maximum takeoff gross weight	570,000 lbs.	769,000 lbs.	837,000 lbs.
Normal operating altitude with maximum payload at 2.25G	33,000 ft.	31,000 ft.	c
Average cruise speed	450 kts.	450 kts.	450 kts.

Description	C-17 Air Force	C-5B Air Force	C-5B Lockheed
Minimum runway requirements: 90° day at sea level, 170,000 lbs. payload, fuel for 500 NM flight			
Field length for takeoff:			
Peacetime	4,360 ft.	5,300 ft.	4,100 ft.
Wartime	3,900 ft.	4,800 ft.	4,100 ft.
Landing distance: Using brakes and spoilers	2,600 ft.	2,700 ft.	2,490 ft.
Using brakes, spoilers, and reverse thrust	2,370 ft.	2,600 ft.	2,370 ft.
Minimum runway width:			
Peacetime	90 ft.	147 ft.	147 ft.
Wartime	60 ft.	90 ft.	90 ft.
Minimum taxiway width:			
Peacetime	50 ft.	75 ft.	75 ft.
Wartime	d	d	50 ft.
Minimum pavement width for 180° turn:			
Without backup maneuvering	114 ft.	140 ft.	140 ft.
With backup maneuvering	80 ft.	e	102 ft.
Utilization rates in flying hours per day:			
Peacetime	3.2 hrs.	2.0 hrs.	N/A
Wartime:			
Surge rate	15.6 hrs.	12.5 hrs.	12.5 - 13.1 hrs.
Sustained rate	13.9 hrs.	10.0 hrs.	10.0 hrs.
Maximum ferry range without payload	5,290 NM	6,720 NM	6,827 NM

Description	C-17 Air Force	C-5B Air Force	C-5B Lockheed
Payload and range without refueling, maximum take-off gross weight held constant			
Maximum takeoff gross weight	570,000 lbs.	769,000 lbs.	837,000 lbs.
Maximum payload	172,200 lbs.	261,000 lbs.	261,000 lbs.
Maximum range	2,940 NM	1,530 NM	2,713 NM
80% maximum payload	137,760 lbs.	208,800 lbs.	208,800 lbs.
80% maximum range	3,500 NM	2,520 NM	3,698 NM
60% maximum payload	103,320 lbs.	156,600 lbs.	156,600 lbs.
60% maximum range	3,850 NM	3,570 NM	4,798 NM
40% maximum payload	68,880 lbs.	104,400 lbs.	104,400 lbs.
40% maximum range	4,250 NM	4,850 NM	5,636 NM
20% maximum payload	34,440 lbs.	52,200 lbs.	52,200 lbs.
20% maximum range	4,720 NM	6,100 NM	6,184 NM
Range with no payload	5,290 NM	6,720 NM	6,827 NM
Critical field length at maximum takeoff gross weight, 90° day at sea level with maneuver load factor of 2.25G			
Maximum takeoff gross weight	570,000 lbs.	769,000 lbs.	837,000 lbs.
Critical field length for takeoff	8,130 ft.	10,400 ft.	10,400 ft.
Critical field length; short airfield takeoff, maneuver load factor of 2.25G, 90° day, sea level, fuel for 500 NM return with 50% maximum payload			
50% maximum payload	86,100 lbs.	130,500 lbs.	130,000 lbs.
Critical field length for takeoff	2,640 ft.	4,500 ft.	3,450 ft.

Description	C-17 Air Force	C-5B Air Force	C-5B Lockheed
Landing distance, short airfield over 50 foot obstacle; 90° day, sea level, fuel for 500 NM return with no payload, all engines operating with maximum reverse thrust			
Maximum payload	172,200 lbs.	261,000 lbs.	261,000 lbs.
Landing distance	2,610 ft.	4,150 ft.	3,580 ft.
80% maximum payload	137,760 lbs.	208,800 lbs.	208,800 lbs.
Landing distance	2,340 ft.	3,850 ft.	3,290 ft.
60% maximum payload	103,320 lbs.	156,600 lbs.	156,600 lbs.
Landing distance	2,080 ft.	3,400 ft.	3,020 ft.
40% maximum payload	68,880 lbs.	104,400 lbs.	104,400 lbs.
Landing distance	1,990 ft.	3,000 ft.	2,750 ft.
20% maximum payload	34,440 lbs.	52,200 lbs.	52,200 lbs.
Landing distance	1,880 ft.	2,650 ft.	2,520 ft.

---

[a]The Air Force states the navigator position will be phased out of the C-5 aircraft by the end of September 1985. A minimum crew of four is required for ferry flights with no payload.

[b]The normal maneuver load factor is 2.25G for the C-17 and C-5B aircraft. It means the aircraft can maneuver inflight increasing the gravity induced weight up to, but not exceeding, 2.25 times the normal 1.00G weight.

[c]Lockheed states C-5B normal operating altitude as a range with the lower altitude (25,600 ft.) at the start of cruise and the higher altitude (31,800 ft.) at the end of cruise.

[d]This is a judgmental decision based on the priorities of a mission and the ground environment.

[e]The Air Force states the C-5A/B lacks an effective backup capability and since there was no design requirement for this capability, it has never been tested.

SMALL, AUSTERE AIRFIELD CAPABILITY

C-5A/B

The original concept of operation envisioned for the C-5A required that it be employed in strategic and tactical roles. However, planned tests to determine suitability for use in a tactical role were not completed because understrength wings were discovered early in the test program. The C-5A has been used in a strategic role exclusively, and the Air Force Master Airlift Plan shows that the C-5A/B will be used only in a strategic role in the future. Military Airlift Command officials stated the C-5A/B is best used as a high volume airlifter that can produce a large flow of airlift between main operating bases. Based upon its experience, the Air Force does not believe that the C-5A/B can routinely and safely land on or takeoff from small, austere airfields.

Lockheed, however, believes the C-5A is now capable of normal short field operations since wing stress is no longer a problem. The understrength wings are being replaced under a $1.5 billion modification program. It stated that the C-5A, in its initial operational testing in the early 1970s, had successfully demonstrated its capability to use 4,000 foot long paved runways for normal flight operations. Lockheed recently proposed to complete the C-5 tests that were deferred in 1970. The purpose of these tests would be to demonstrate and validate the full operational capabilities required by the Air Force in the original C-5A design as well as capabilities exceeding the original requirements. The Air Force is presently evaluating the Lockheed offer.

According to the Air Force, small, austere airfields typically include the following features.

--Runways are usually less than 4,000 feet long and can be as narrow as 60 feet.

--Payloads may be constrained by runway length and weight bearing capacity.

--There is less than 100,000 square feet of ramp space accessed by way of a single narrow taxiway and there are no turnaround areas at either end of the runway.

--Ground support and equipment are usually nonexistent.

The C-5B's estimated critical field length is 10,400 feet with 261,000 pounds of cargo and a maximum gross weight of 769,000 pounds at sea level on a 90-degree fahrenheit day, according to Air Force data. The C-5B critical field length for a short airfield takeoff with 50 percent of its maximum cargo load of 130,500 pounds at sea level on a 90-degree fahrenheit day, with fuel for a 500 nautical mile return, is 4,500 feet, according to the Air

Force, and 3,450 feet, according to Lockheed. Critical field length is the total runway length required to accelerate on all engines to critical engine failure speed, experience an engine failure, then either continue or stop the takeoff.

The Air Force states that the C-5B can land in 4,150 feet with cargo weighing up to 261,000 pounds, and in 2,650 feet with 52,200 pounds, 20 percent of its maximum cargo load. Lockheed's data, which is based on the C-X RFP landing rules, show that the C-5B can land in 3,580 feet with cargo weighing 261,000 pounds, and in 2,520 feet with 52,200 pounds. These performance estimates are based on operating at sea level on a 90-degree fahrenheit day, with enough fuel to return to a location 500 nautical miles away.

While it acknowledges that under limited weight and weather conditions, the C-5A/B takeoff distance or landing roll is less than 3,000 feet, the Air Force has established a minimum runway length of 5,000 feet. The Air Force states that short field operations would involve operating near the limits of aircraft and aircrew capability with very little margin for safety.

The Air Force says that such landings would require consistent precision touchdowns in the first 500 feet of runway and that this is a difficult maneuver in an aircraft the size of the C-5A/B. The Air Force says that it has found that a touchdown zone of 1,000 feet is the minimum practical for the C-5A and that 13 years of operational experience with the C-5A have indicated that 5,000 feet is the minimum runway length that should be used for prudent and safe operations on a routine basis.

Occasionally, exceptions to this 5,000 feet restriction can be made, according to the Air Force, on a case-by-case basis after a careful analysis or survey of the runway width, airfield environment, obstructions, and ramp space. The Air Force has indicated that this restriction will continue to be applied to the rewinged C-5A and the new C-5B.

C-5A/B ground operations on small, austere airfields would be difficult and, in many cases, impossible, according to the Air Force, because of the aircraft's large turning diameter and size. The Air Force states that small airfields are designed for small aircraft and typically do not have the obstruction clearances necessary for an aircraft the size of the C-5A/B, which requires a minimum turning width of 143 feet to make a 180-degree turn. It has a 342-foot wing-tip turn diameter and a 379-foot horizontal stabilizer turn diameter, which makes it difficult to make 180-degree turns on the small parking ramps typical of small, austere airfields when there are nearby obstacles.

Small, austere airfields typically have narrow taxiways, with 50-foot wide taxiways being the most common. The C-5A/B turn radius will not permit a turn from a 50-foot wide runway onto a

50-foot wide taxiway without the landing gear leaving the pavement. Turns from a 90-foot wide runway onto a 50-foot wide taxiway can be made without the landing gear leaving the pavement, provided ground personnel can assist the pilot in making such a precise turn.

Because of its large size and required turning radius, the C-5A/B requires a relatively large ramp space. The amount of ramp space required for an aircraft is dependent upon several factors, such as wing-tip clearance requirements, jet blast considerations, clearance for loading and unloading, other aircraft departures and arrivals, and obstructions near the ramp. Therefore, it is difficult to generalize about ramp space requirements, especially as it pertains to those that may be found at small, austere airfields. For contingency planning, the Air Force uses 193,300 square feet of paved ramp space for each C-5A/B. The manufacturer states that three C-5A/B aircraft can park in an area of about 208,000 square feet when the wings and tail are allowed to overhang the ramp.

The Air Force restricts the C-5A to use on paved runways, even though tests have shown that it can perform some off-pavement ground operations under certain conditions. The Air Force has stated that it cannot rely on an off-pavement capability from the C-5 or any other aircraft in wartime. It states that soils around airfields in many parts of the world will not support aircraft landing gear. Also, solid soils can be rendered unusable by precipitation. The Air Force plans to operate the C-5A/B on paved runways for routine and sustained operations. While off-runway operation is an available option in some situations, the Air Force will not base wartime operations on its use.

The capability of an aircraft to backup under its own power greatly enhances its capability to operate in confined areas or on narrow runways. The Air Force does not consider the limited backup capability of the C-5A/B to be operationally effective because it only reverses its fan thrust rather than both the fan and core thrust. It states that a C-5, when nearly empty of cargo and fuel, is physically capable of backing up under its own power. However, according to the Air Force, the high engine power settings, necessary for aircraft movement in reverse, create a high foreign object damage potential and are potentially damaging to the aircraft structure. It also states that jet blast and high temperature would have an adverse effect on nearby aircraft, personnel, and equipment. For example, at normal breakway engine power, the jet-wake velocity is 100 miles per hour, 175 feet behind the engines, and the temperature is 200 degrees fahrenheit at about 55 feet. The ability of the C5A/B to backup is one of the tests recently proposed by Lockheed.

C-17

According to both the Air Force and McDonnell Douglas Corporation, the C-17 is designed to land in 2,610 feet with 172,200 pounds of cargo and in 1,880 feet with 34,440 pounds--20 percent of its maximum cargo payload. This performance is based on operating at sea level on a 90-degree fahrenheit day with enough fuel to return to a location 500 nautical miles away.

The C-17's estimated critical field length is 8,130 feet with 172,200 pounds of cargo and a maximum takeoff gross weight of 570,000 pounds at sea level on a 90-degree fahrenheit day. The C-17 will have a critical field length of 2,640 feet for a short airfield takeoff with 50 percent of its maximum cargo load of about 86,100 pounds at sea level on a 90-degree fahrenheit day with fuel for a 500 nautical mile return.

The Air Force believes the C-17 will be clearly superior to the C-5B in overall capability to operate through small, austere airfields. The C-17's advantages in the small, austere airfield environment include its smaller size, better maneuverability using its backup capability, and its combat offload capability. The Military Airlift Command states the C-17 will be able to perform any type of mission currently assigned to the Command including tactical airlift missions currently performed by the C-130.

According to the Air Force, the C-17 will have several unique design feature, which contribute to its capability to takeoff, land, and operate on small, austere airfields. These features include

--externally blown wing flaps, which lower airspeed and reduce takeoff and landing distance;

--directed-flow thrust reverser system for braking at all speeds down to zero, for ground maneuvering, and for inflight deceleration;

--head-up display which permits more precise landing touch-down accuracy; and

--high flotation landing gear designed for a 16.5 feet per second rate of descent to permit landing with heavy payloads into short airfields using a steep approach angle at low airspeed.

Successful use of externally blown flaps and directed-flow thrust reversers was demonstrated on McDonnell Douglas's YC-15 prototype Advanced Medium Short Takeoff and Landing Transport Aircraft demonstration program in the mid-1970s.

The Air Force believes that the C-17's smaller size and maneuverability on the ground will enable it to operate on narrow runways, taxiways, and small parking ramps typical of small, austere airfields. The C-17 will be 175 feet long and have a wing span of 165 feet. The wing tip turning diameter of the C-17 will be 234 feet and the horizontal turning diameter will be 237 feet. It will be able to make a 180-degree turn in a minimum width of 114 feet without backing up and in 80 feet using backup maneuvering. The C-17 will require less ramp space than the C-5A/B because of its smaller wing tip and horizontal stabilizer turning radius and backup capability. The manufacturer states that three C-17 aircraft will be able to park in an area of about 81,400 square feet when the wings and tail are allowed to overhang the ramp.

Use of C-17's externally blown flaps results in the engine fan and exhaust airflow being turned downward by the flaps which creates lift. Use of externally blown flaps in conjunction with the spoilers results in a 20-knot reduction in approach and landing speeds. Powered lift supplements the conventional wing lift and makes it possible to takeoff and land in shorter distances because of reduced aircraft speeds.

According to the Air Force, the unique engine thrust reversing system on the C-17 will provide several advantages which enhance its capability to operate at small, austere airfields. On the C-17, when both the cool fan air and the hot engine core air are reversed, they provide more thrust than if only the fan air is reversed, as on the C-5A/B. The air is directed forward and upward and, consequently, will not blow up sand, dust, rock, and other debris, and will also minimize reingestion of harmful hot exhaust gases. In addition, the thrust reverser will operate to zero forward speed and permit the C-17 to backup while carrying its maximum cargo load. This backup capability will allow very close maneuvering on the ground.

The thrust reversers, together with the relatively small size of the C-17, will facilitate parking on small, crowded ramps for loading or unloading. Using reverse thrust, the engines can be kept running at idle while simultaneous cargo and service operations are underway without exposing ground crew, equipment, or nearby aircraft to harmful jet blast.

The C-17 will have several features that are expected to enable it to make very precise touchdowns. This is critical in using small airfields with short and narrow runways. The C-17 will have a head-up display that provides critical flight information to the pilots while they are looking directly at the runway and aiming and controlling the aircraft toward a specific touchdown spot on the runway. In making a short field landing, the C-17 will be able, using a 5-degree glide slope, to land within 150 feet of a selected touchdown spot with its maximum payload.

OTHER PERFORMANCE CAPABILITIES

Some of the other important performance capabilities of the C-5A/B and C-17 are discussed below.

C-5A/B

The Air Force and Lockheed state that the C-5B is capable of taking off with a maximum cargo load of 261,000 pounds and flying 1,530 and 2,713 miles, respectively. The Air Force estimate is based on the currently approved maximum takeoff gross weight of 769,000 pounds, while Lockheed's is based on maximum potential takeoff weight capability of 837,000 pounds. This difference in weight is attributable only to increased fuel carrying capacity. The Air Force has not decided whether it will increase its currently approved C-5A/B maximum takeoff gross weight and is presently considering the Lockheed flight test proposal to validate this capability.

The Air Force states that the critical field length for the C-5B is 10,400 feet with a maximum takeoff gross weight of 769,000 pounds, which includes 261,000 pounds of cargo. Lockheed data shows that the critical field length is 10,400 feet at a maximum takeoff gross weight of 837,000 pounds, including 261,000 pounds of cargo. Both estimates of critical field length are based on operating at sea level on a 90-degree fahrenheit day.

The C-5A/B does not have low altitude parachute extraction system (LAPES) or combat offload capability and these capabilities were not a design requirement for the C-5A/B. Lockheed states that these capabilities can be incorporated, however, with minor aircraft modification. The Air Force states that special procedures, techniques, and equipment could be developed that would give the C-5A/B a limited LAPES capability but questions its operational utility due to high potential for aircraft and cargo damage. During a LAPES operation, the aircraft flys very close to the ground and cargo is pulled out the rear of the aircraft by parachutes. Combat offload involves the unloading of cargo from the rear aircraft ramp while the aircraft is slowly moving on the ground.

The C-5A/B has the capability to airdrop cargo and paratroopers. The Military Airlift Command stated that this capability was adequately demonstrated in the C-5A test program. Although final testing by operational crews was not completed because of the discovery of wing cracks, the capability was verified and can be used if required.

APPENDIX II

C-17

The C-17 will be capable of taking off with a maximum cargo load of 172,200 pounds and flying 2,940 miles without refueling. Maximum takeoff gross weight is 570,000 pounds, which consists of cargo weight, aircraft operating weight, and fuel. The C-17 will cruise at an average speed of 450 knots and fly at a normal operating altitude of 33,000 feet with its maximum payload.

The C-17 has been designed to airdrop paratroopers and outsized equipment and will have a LAPES capability. It is also designed to have a combat offload capability.

OBJECTIVES, SCOPE, AND METHODOLOGY

We initiated this review because of statements made during congressional deliberations since the C-X (now C-17) was first proposed in 1980. Questions were raised concerning the need for the C-17 when the C-5 was to have similar capabilities. Our objectives were to develop information on the overall operating capabilities of the C-5B and C-17, giving emphasis to their capabilities for operating into small, austere airfields.

With the assistance and agreement of the Air Force and aircraft manufacturers, we identified significant C-5B and C-17 characteristics and performance capabilities. The Air Force's using command, its system program offices, and the aircraft manufacturers provided us data for their respective systems.

We reviewed documentation from the Air Force and aircraft manufacturers which showed performance data on each aircraft system. We also discussed each system's capabilities with the Air Force's using command, its system program offices, and the aircraft manufacturers.

We performed our work from July to December 1983 at Headquarters, United States Air Force; Headquarters, Military Airlift Command; and the C-5B and C-17 system program offices at Wright-Patterson Air Force Base, Ohio. We also visited a C-5A operational base in Dover, Delaware, and the aircraft manufacturers' plants in Long Beach, California, and Marietta, Georgia.

We did not review the productivity or cost effectiveness of each aircraft in meeting a given set of requirements. The productivity of each aircraft is highly dependent on the requirements to be met and the operational capability attributed to each system.

We obtained informal comments on a draft of this report from the Air Force C-5 and C-17 program offices, the Air Force Military Airlift Command, the Lockheed-Georgia Company, and the McDonnell Douglas Corporation. We did not request formal comments from either the Department of Defense or the contractors.

(951780)